SAIC Analysis of Data Acquired at Camp Butner, NC

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ESTCP

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14. ABSTRACT
The Large Scale Classification Project at Camp Butner provides an excellent opportunity to compare and contrast classification performances for static and reconnaissance EMI data and for a variety of analysis approaches. SAIC analyzed EM61 data acquired in reconnaissance mode as well as Metal Mapper and TEMTADS data acquired while stationary. Our analysis included single- and multi-source solvers. Our classification utilizes a decision tree targeting the intrinsic polarizabilities. The decision tree incorporates uncertainty in unanticipated targets-ofinterest and has hasn?t changed dramatically since being developed using data acquired at Aberdeen Proving Ground, Camp Sibert, and Camp San Luis Obispo. We also experimented in the number of training labels (starting with no on-site labels) used to fine tune the classifier. Finally, we utilized two different analysis environments; Oasis montaj and IDL. Two commercial firms, NAEVA and Parsons, also utilized the UX-Analyze module in Oasis montaj to classify Metal Mapper stationary data. During our presentation, we will discuss performances of the various combinations and present lessons learned.

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SAIC DATA ANALYSIS OF DATA ACQUIRED AT CAMP BUTNER

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Outline

Background

    Datasets analyzed

    Analysis environment

    Inversion schemes

    Classification approach

EM61 data as pre-screen

Classification performance

Failure Analysis

Stop by Poster #61 for more details

Project Team & Sponsor

Science Applications International Corporation (SAIC)

Dean Keiswetter	program manager
Tom Furuya	data analyst
Jim Kingdon	data analyst & analysis algorithms
Nagi Khadr	data analyst
Jonathan Miller	analysis algorithms
Bruce Barrow	failure analysis
Tom Bell	technical advisor

Supported by ESTCP Project's MM-0910 & MM-0134

Sensor Data

Dynamic

Cued

EM61

MetalMapper

TEMTADS
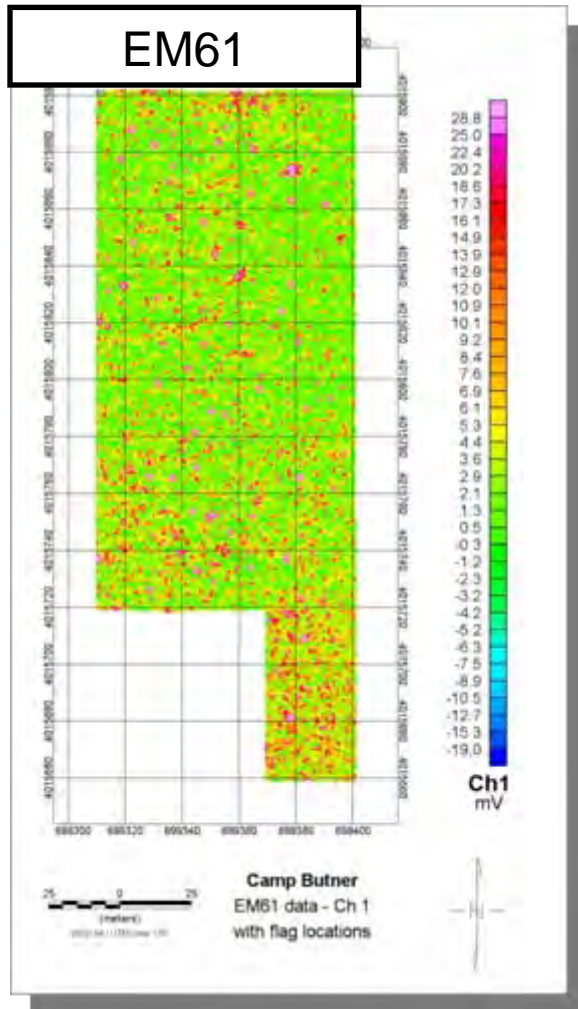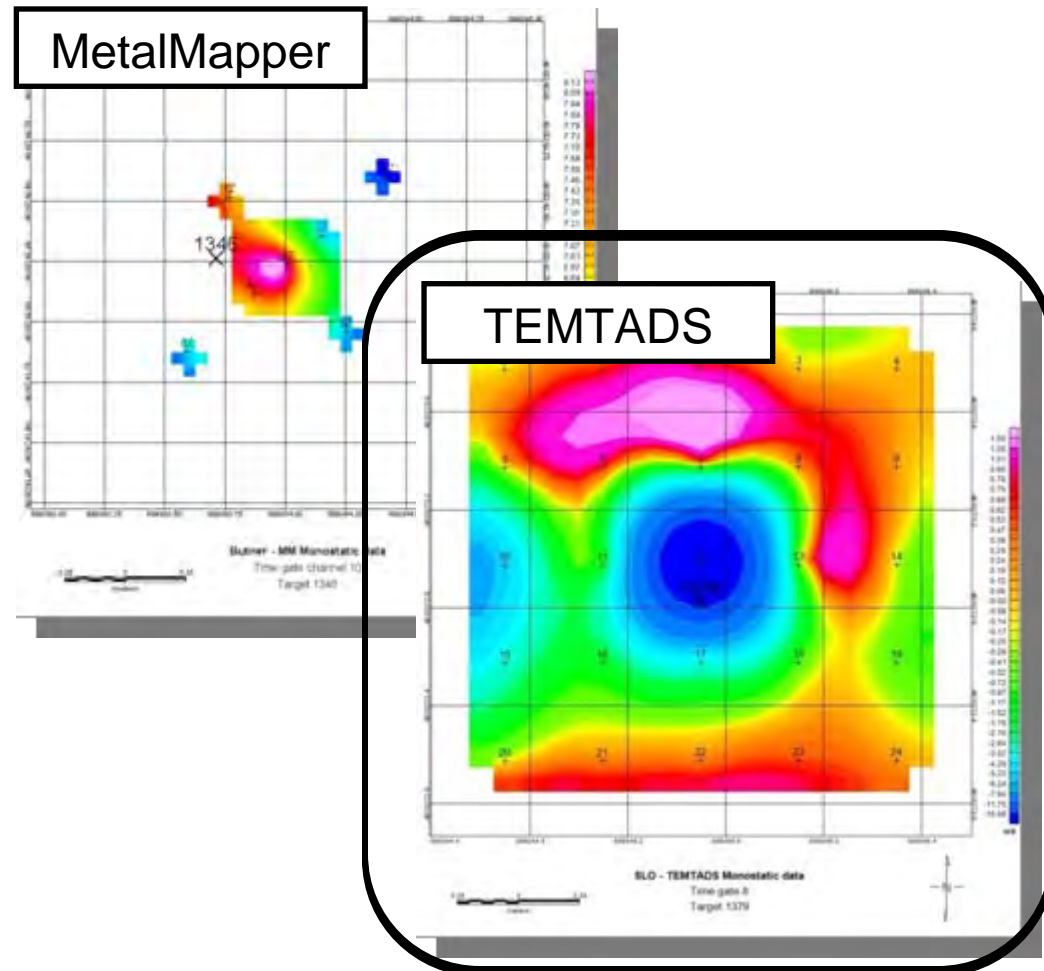
Analysis Environment

UX-Analyze

Stop by Poster #60 for more details

Oasis montaj
- High performance database
- Advanced data processing
- Dynamic linking (maps, data, profiles, etc.)
- Professional map production
- Audit trail
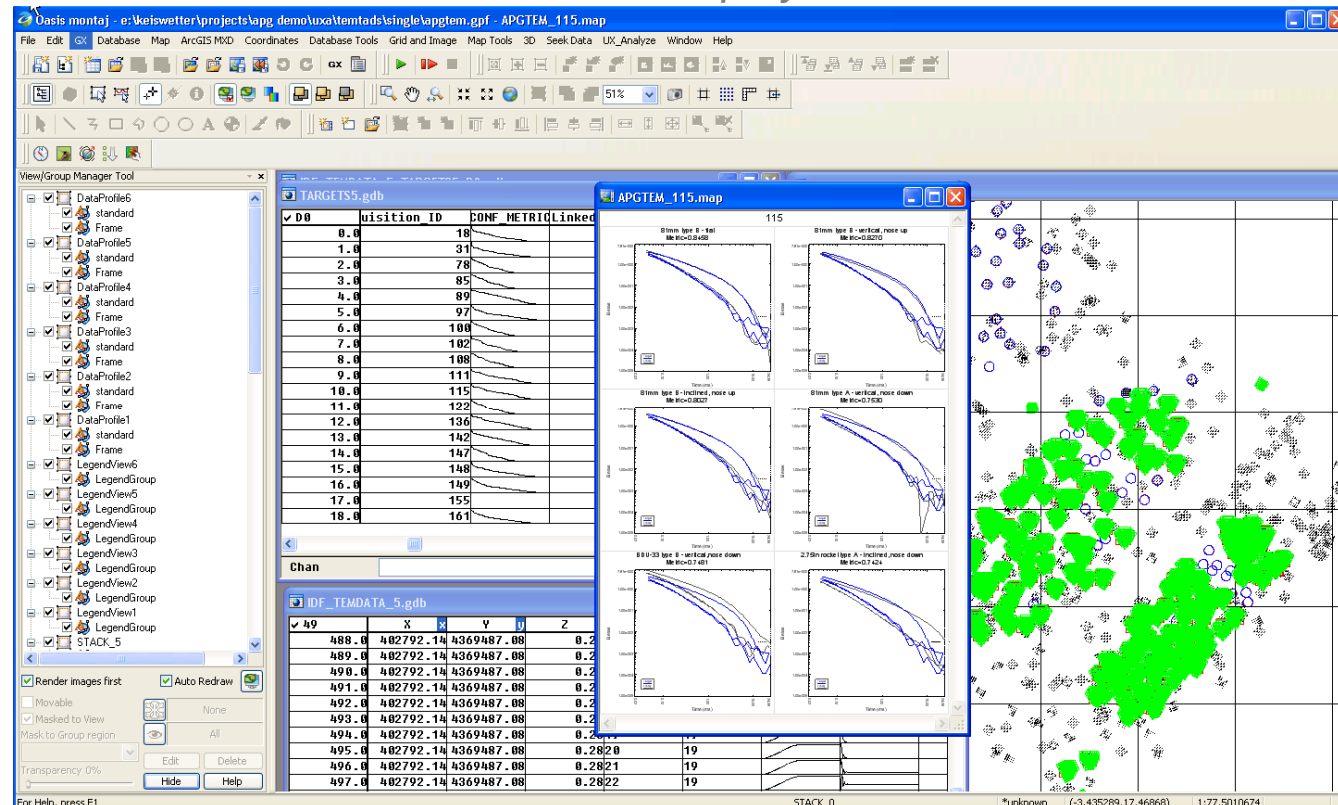
Single target solvers

Standard dipole model

- Location (X,Y,Z), orientation (Ψ, Θ, Φ), & intrinsic polarizabilities

Utilized two single source, but multi-stage solvers – each designed to avoid local minima

♦ Generally produce the same answers

♦ Subtle difference in recovered polarizabilities are sometimes observed

♦ Excellent data for establishing best practices

Multi-source Solver

Multi-source solver for handling multiple objects within the sensors' field of view (MM-1662)

- ♦ Seed the area with sources
- ♦ Predict signals with forward model
- ♦ Find a linear combination that best match observed signal using sparse solution solver
- ♦ Add new seeds
- ♦ Iterate

Perform multi-dipole inversion on derived target locations

7
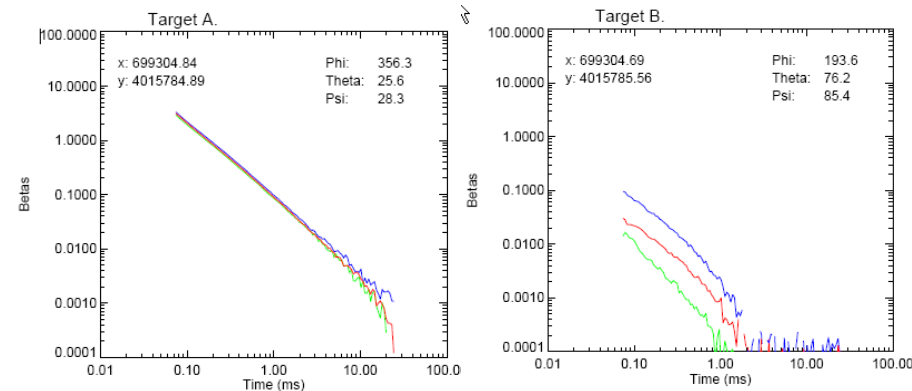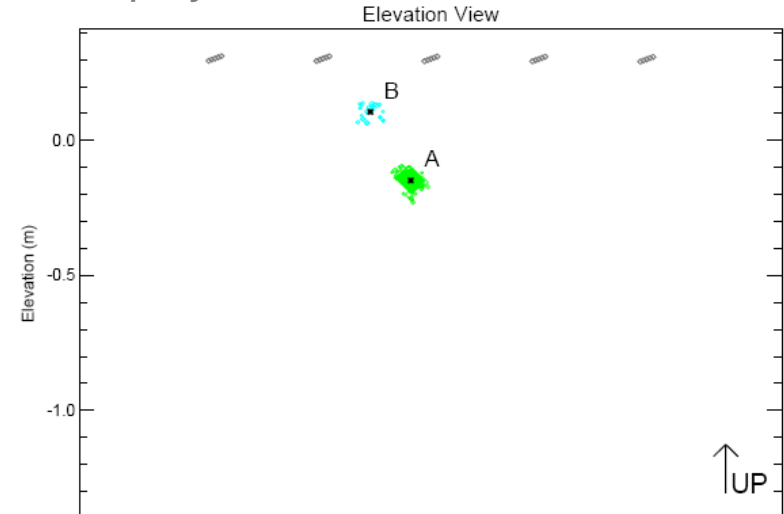
Classification Approach
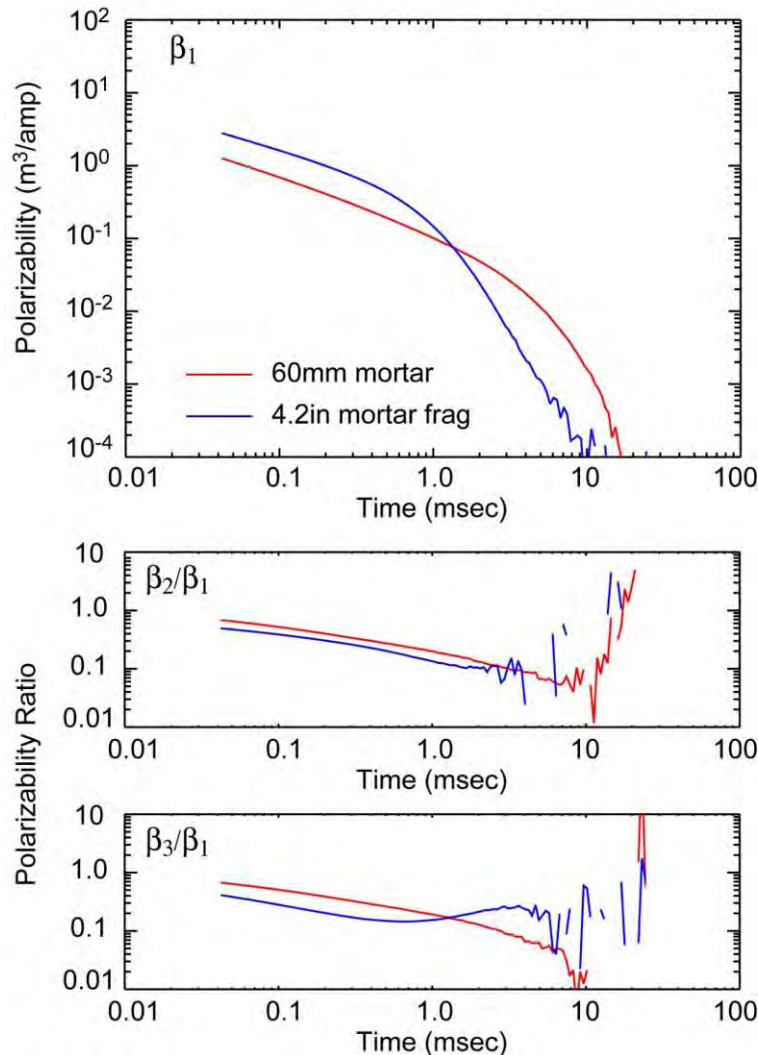
- Compare unconstrained polarizabilities for the target under investigation to a signature library

- "Library match" metric

    1. Primary polarizability (β_1)

    2. Ratio secondary to primary (β_2/β_1)

    3. Ratio tertiary to primary (β_3/β_1)

- Decision boundary chosen to accommodate training data

Axial Symmetry

- Targets with axially symmetric response that do not match expected munitions included in "can't decide"
  - ♦ Hedge against unexpected munitions (e.g. 3" Stokes mortar)
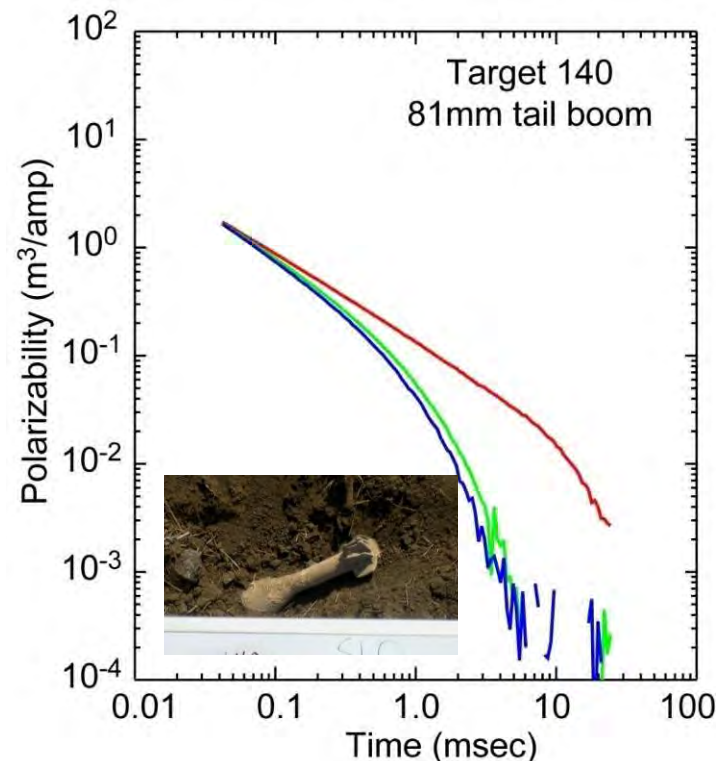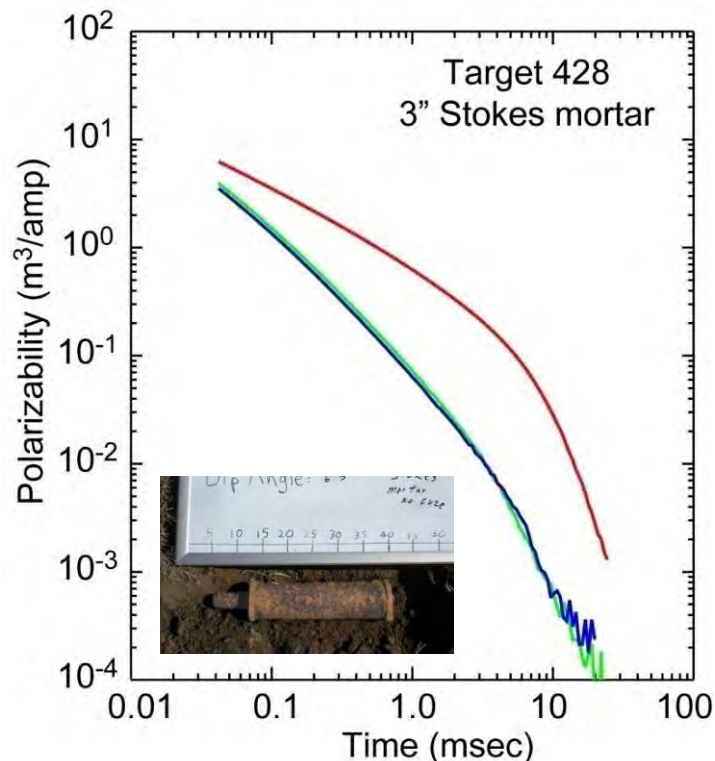
EM61 as pre-screener

- Lower coil only, four gates
- Unconstrained 3-polarization
- Identified high confidence
  - UXO → dig
  - Clutter → leave
- All others request cued data
- Classification based on
  - ◆ Size ($\sum \beta$ 1st time gate)
  - ◆ Measured decay
  - ◆ Screen on fit quality
  - ◆ Generalized likelihood ratio test to assign probabilities
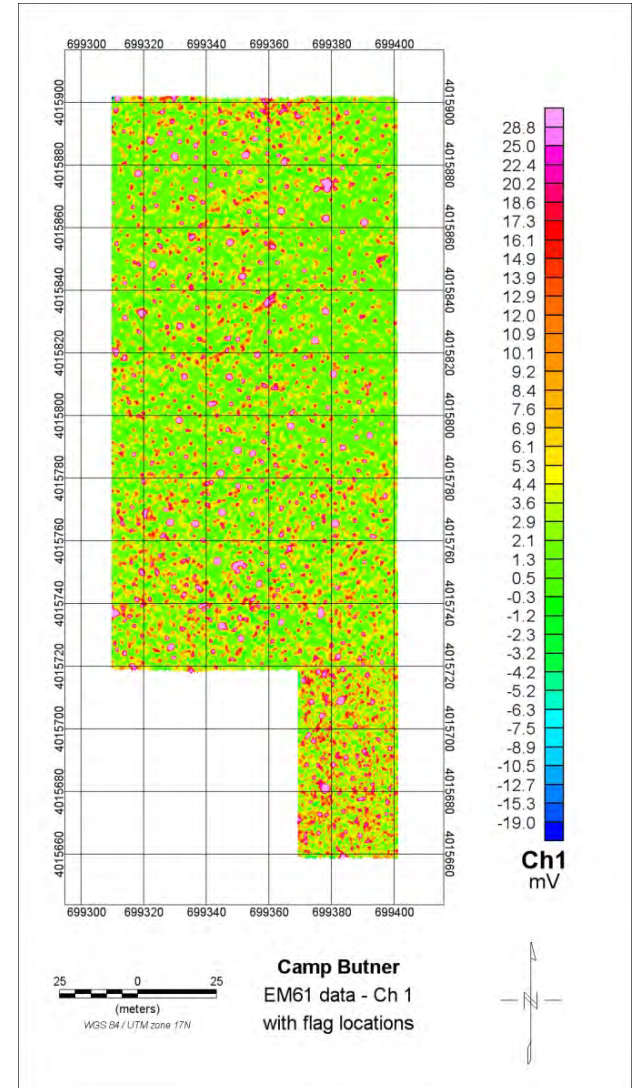
Camp Butner
EM61 data - Ch 1
with flag locations

EM61 as pre-screener

	UXO	CLUTTER
Declared	68	251
Actual	59	249

Camp Butner - EM61 cart Ch1 - Anomaly 404

Fit size vs Decay constant (Ch4/Ch1)

Legend:
- 105mm from test pit
- M48 from test pit
- 37mm from test pit
- potential 105mm
- potential M48
- potential 37mm
- potential clutter
- good isolated anomaly

Classification Performance

Butner SAIC UX-Analyze None TEMTADS None v1 TOI
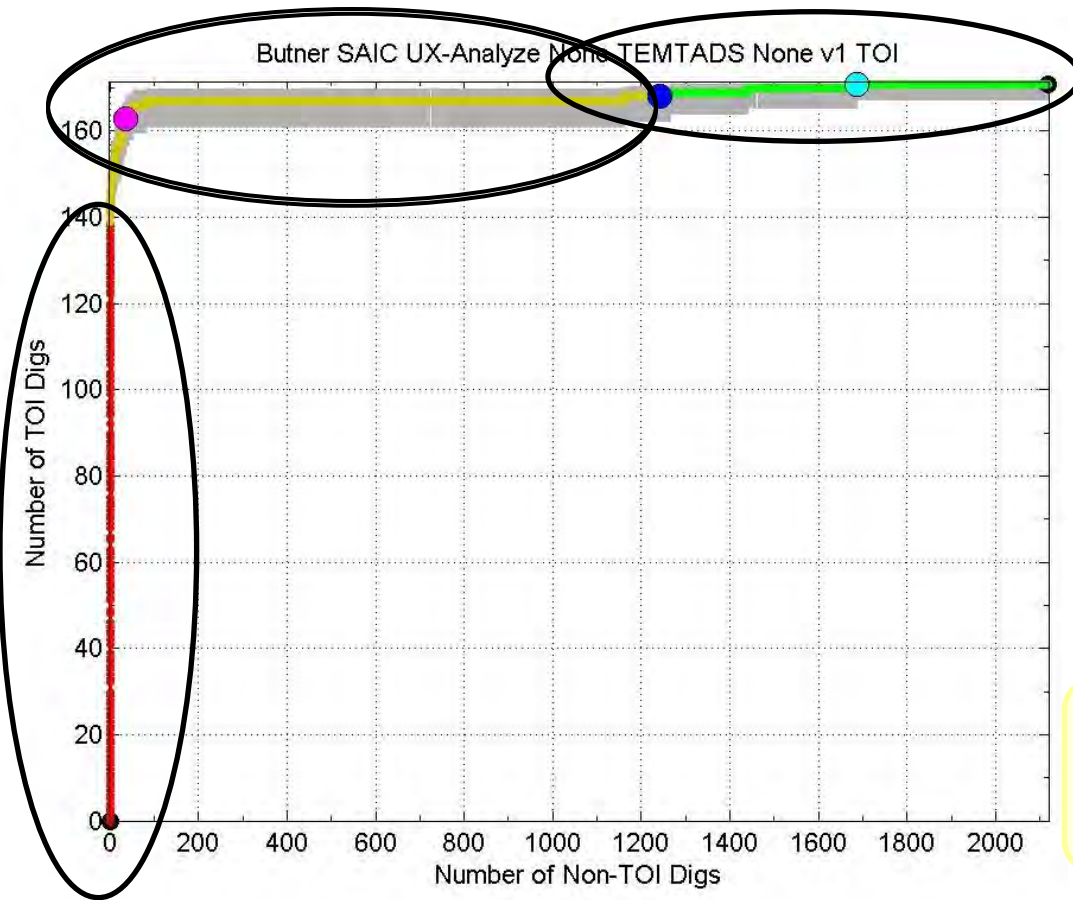
2,290 anomalies

- ♦ 0 training
- ♦ 0 can't analyze

1,021 classified

- ♦ 139/142 munitions correctly classified (97.9%)
- ♦ 877/879 clutter correctly classified (99.8%)

1,269 can't decide

- ♦ 29 UXO, 1,240 clutter

Signature Variability

37mm mortars

M48 fuze

105mm projectile
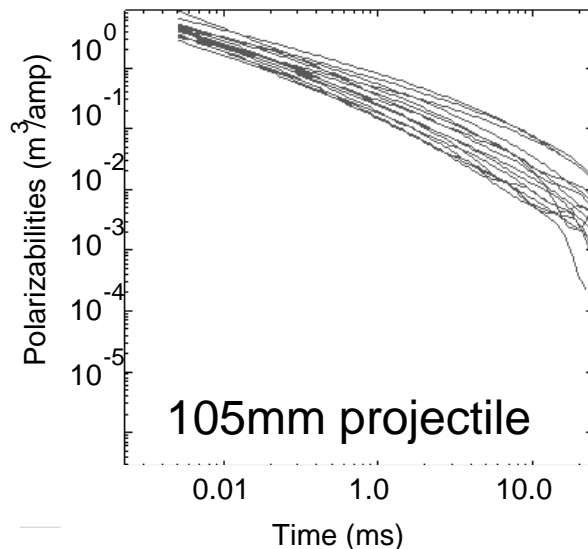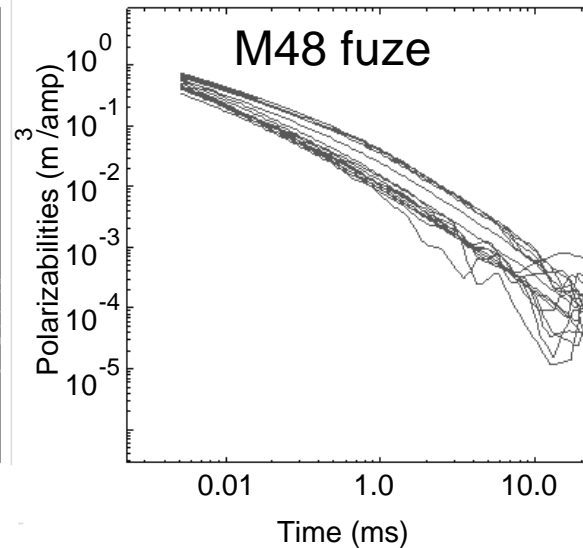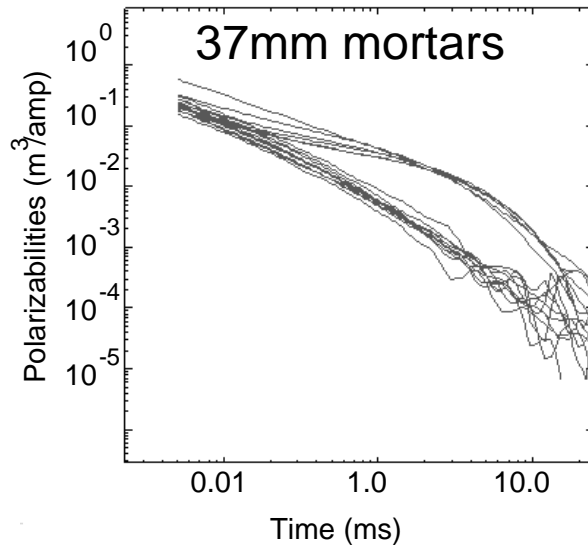
- Munitions in each class (37mm, M48, 105mm) are not identical

- Response curves can vary due to target condition: different model, fuze & tail boom present/absent, *etc.*

Correctly Classified as UXO	
37mm	118
M48 fuze	24
105mm	26
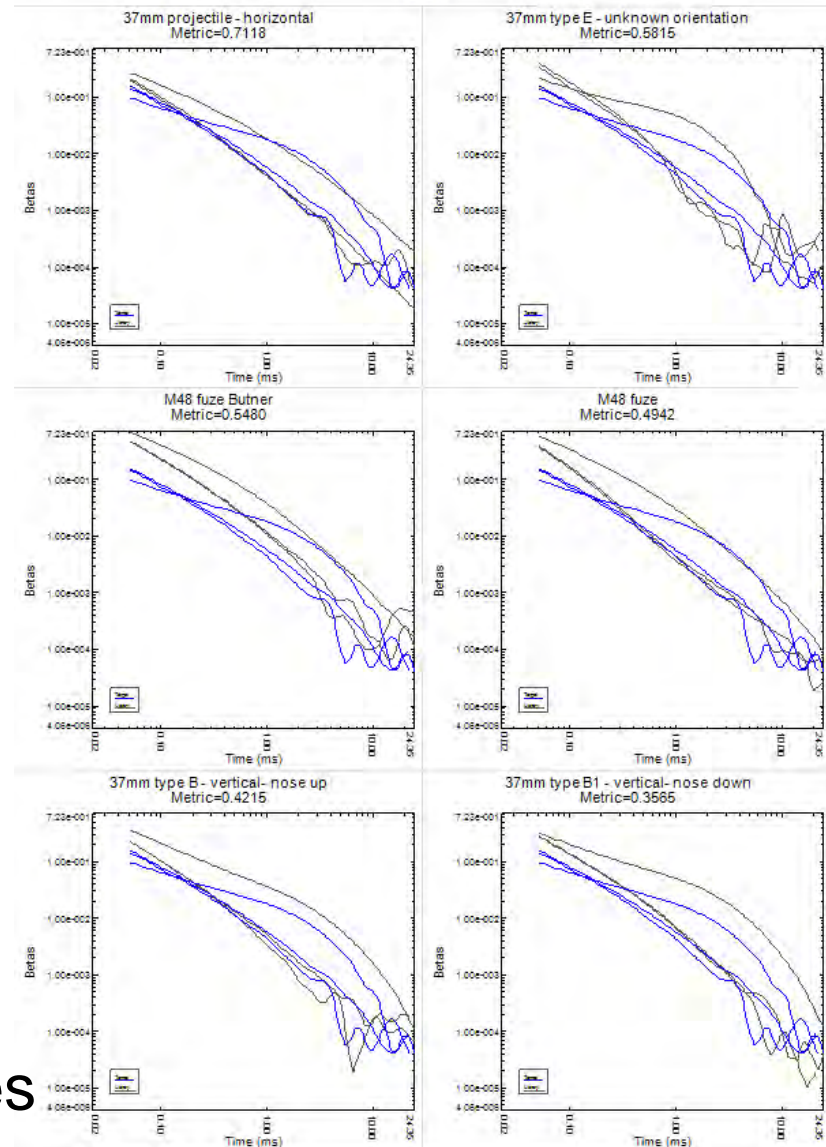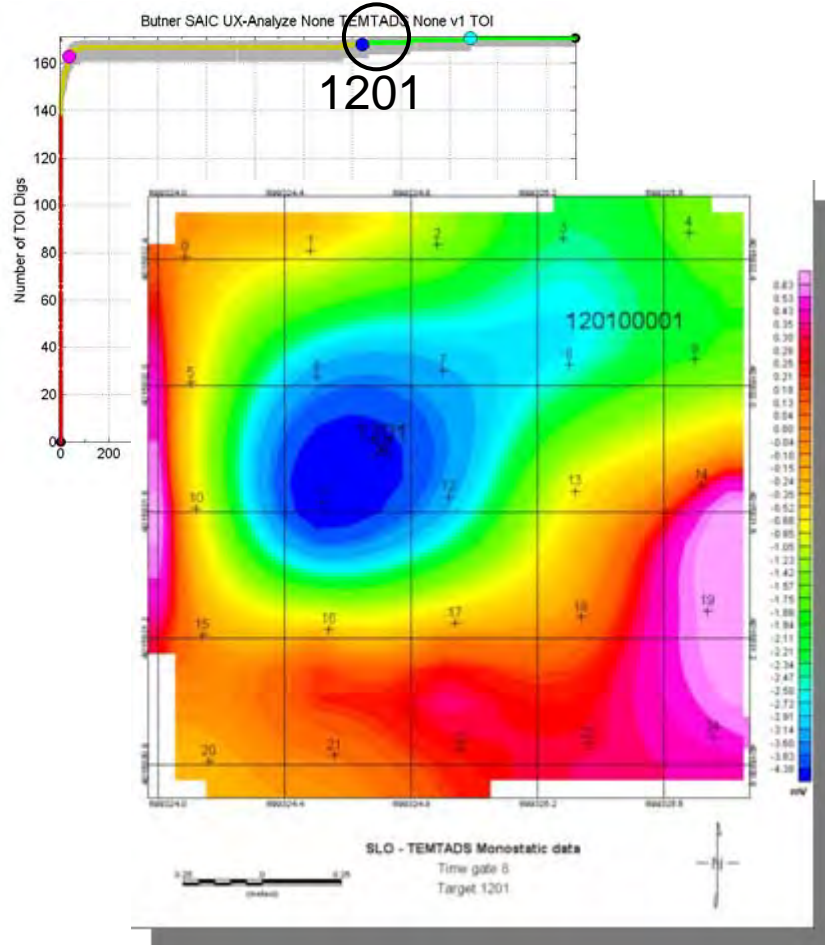
Signature Comparison:

ID 1201 versus library signatures

1201

Principal polarizability crosses the other two

Not in our library

Symmetry metric based on polarizations 1 & 2 instead of 2 & 3
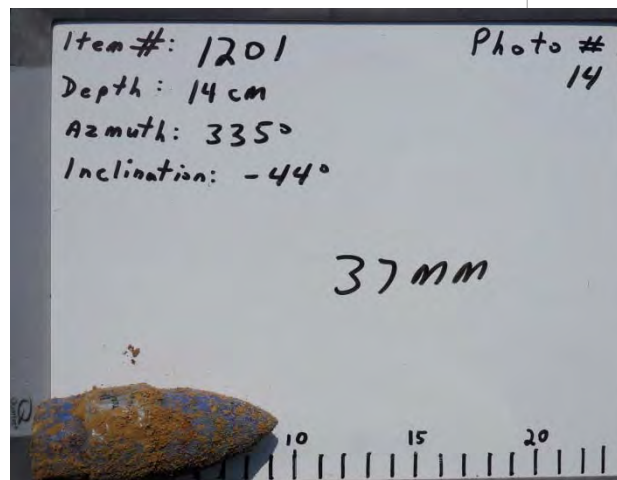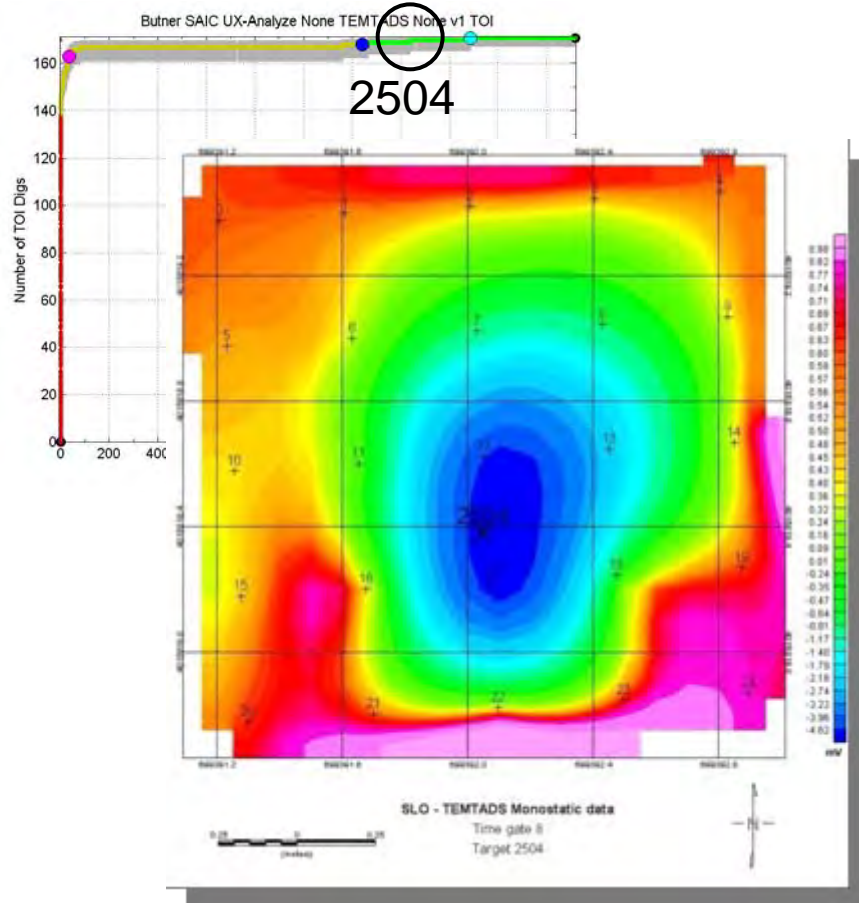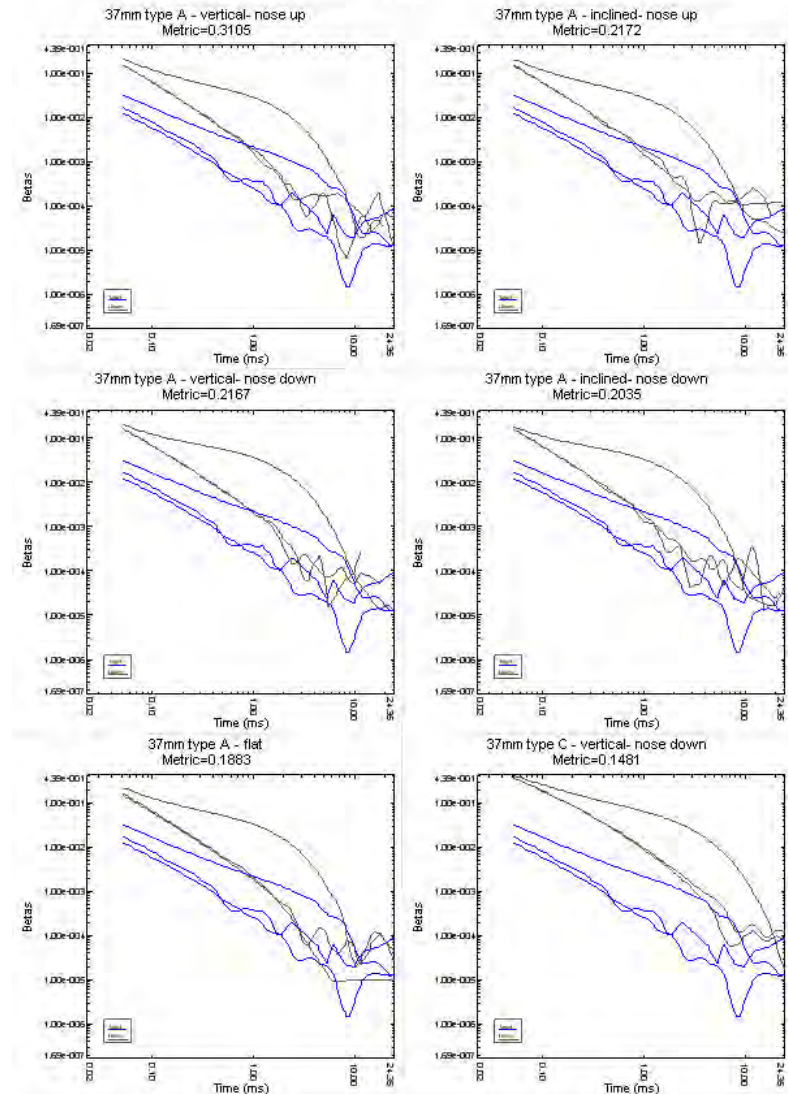
Signature Comparison:

ID 2504 versus library signatures

Classified as clutter based on size

Inverted depth and polarizabilities too small

Signature Comparison:

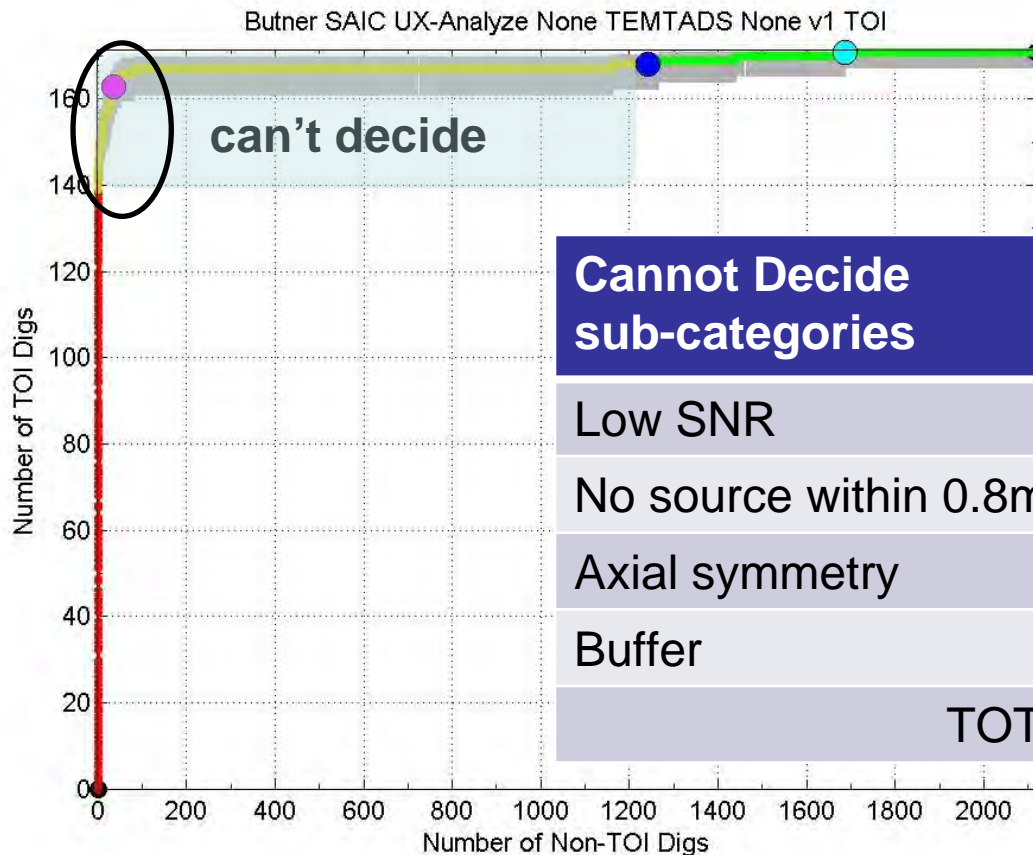ID 429 versus library signatures
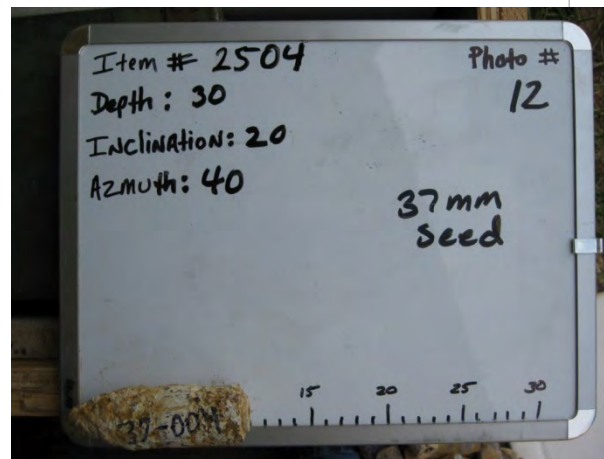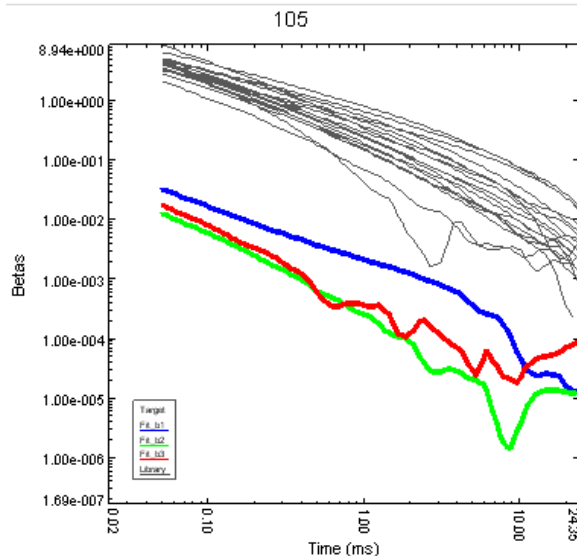
Misclassified Munitions (3 of 3)

Decision metric of 0.80, just below our threshold of 0.81.

Decent signal strength put it in the high confidence clutter category

"Can't Decide" Category

Butner SAIC UX-Analyze None TEMTADS None v1 TOI

can't decide

Number of TOI Digs (y-axis)
Number of Non-TOI Digs (x-axis)
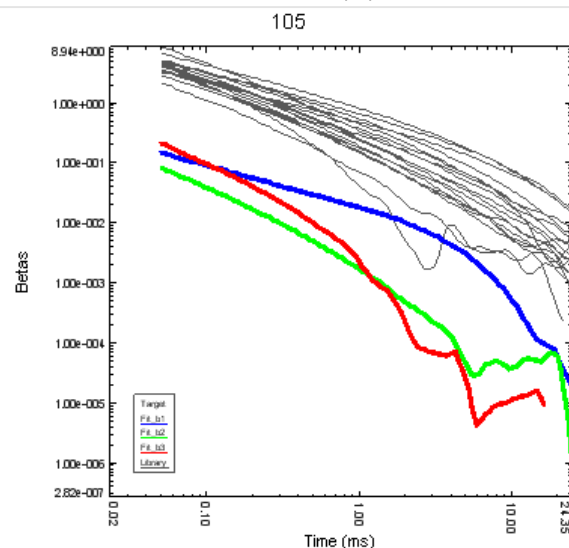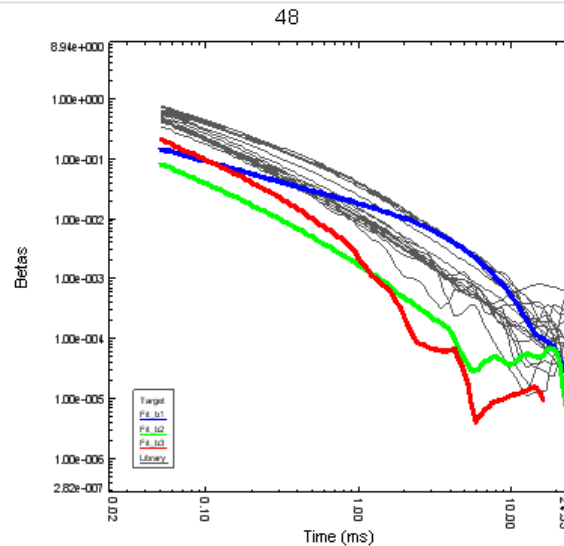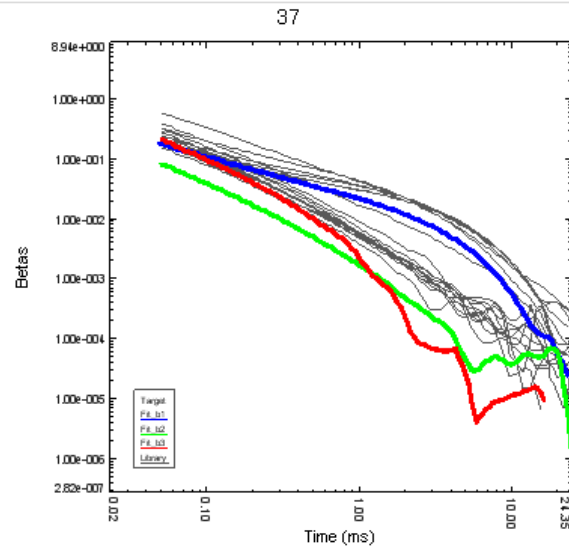
Cannot Decide sub-categories	Total Count	No. of UXO
Low SNR	141	1
No source within 0.8m	25	0
Axial symmetry	1059	8*
Buffer	44	20
TOTAL	1269	29

*modifying our UXO/clutter threshold and not hedging for unexpected munitions types (viz., axial symmetry) would have reduced the unnecessary digs by 951

Summary/Conclusions

Our attempt to conservatively pre-screen using EM61 data (inverted size & measured decay) resulted in two false negatives

Classification based on intrinsic polarizabilities is effective

The vast majority of UXO were readily classified
- ♦ 37mm showed the most variability and were the most difficult for us

Areas for classification performance improvement
- ♦ Low SNR targets – Longer stacks, more robust classifier
- ♦ Multiple targets – Adaptive array positioning, improved multi-target solvers
- ♦ Misclassified munitions – Consolidate and adopt program-wide best practices for recognizing and dealing with outliers

Analysis Interface

Solver Documentation (*.pdf)

NRL TEM array
Number of targets: 2

Plan View

B
x: 699304.69
y: 4015785.56
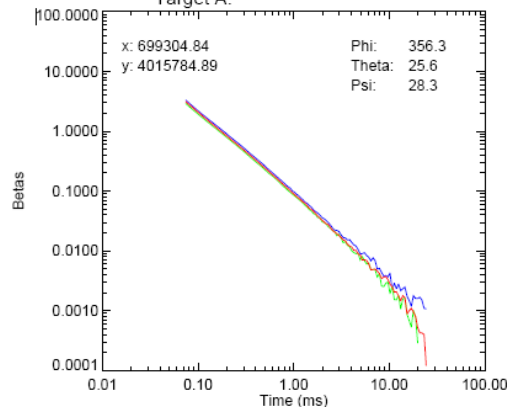z: -0.20

A
x: 699304.84
y: 4015784.89
z: -0.45

N
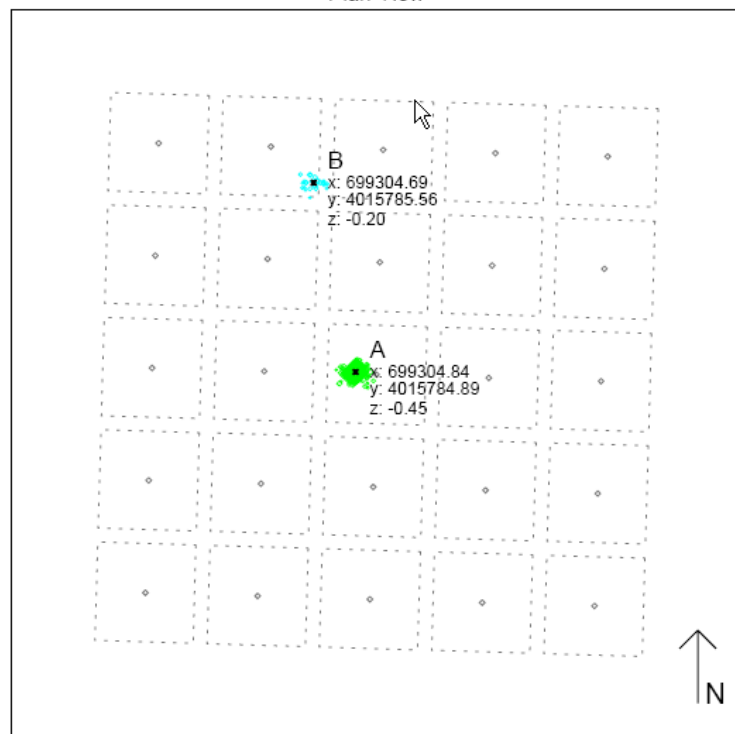
Archive Documentation for each anomaly processed

Elevation View

B

A

UP

Target A.
x: 699304.84   Phi: 356.3
y: 4015784.89   Theta: 25.6
                Psi: 28.3

Target B.
x: 699304.69   Phi: 193.6
y: 4015785.56   Theta: 76.2
                Psi: 85.4

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